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(71) Applicant
Kineron Gauging Systems Ltd

(Incorporated in the United Kingdom)

Abex Road, Newbury, Berkshire, RG14 5EL,
United Kingdom

(72) Inventor
Michael William King

(74) Agent and/or Address for Service
F J Cleveland & Co
40-43 Chancery Lane, London, WC2A 1JQ,
United Kingdom

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(54) Thickness measurement device

(57) Thickness measuring apparatus for accurately measuring the thickness of a flat object such as a sheet material. The apparatus includes a radiation type measuring device (15), e.g. a laser type device which can measure the distance to a first surface of the object and an eddy current type device (16) which can measure distance to the other surface of the object. The thickness is obtained by subtracting the two distances. The eddy current type device has an open central region so that the radiation type device can be located generally coaxially with it. This arrangement minimises errors when the apparatus is moved relative to the object.

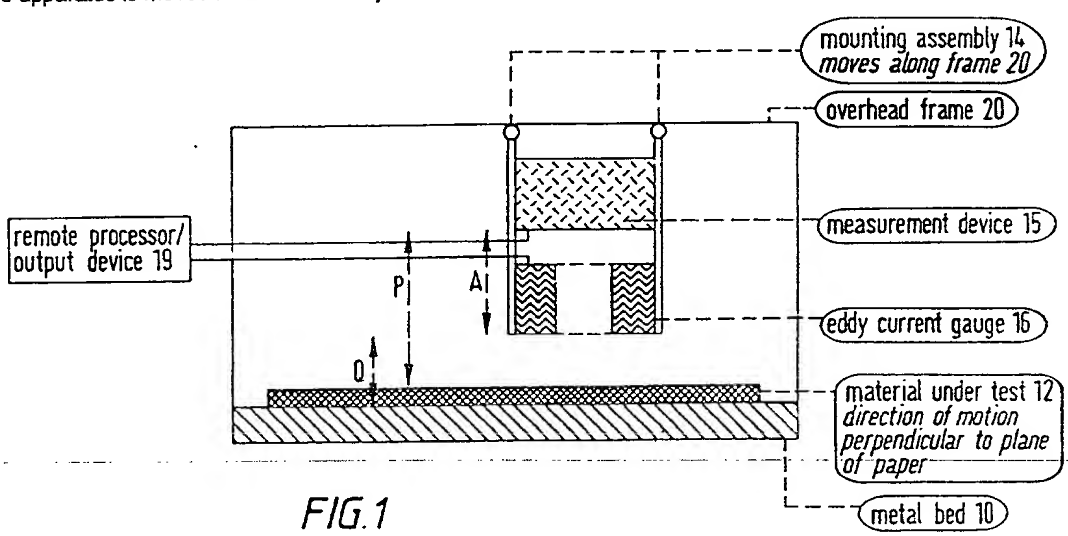

FIG.1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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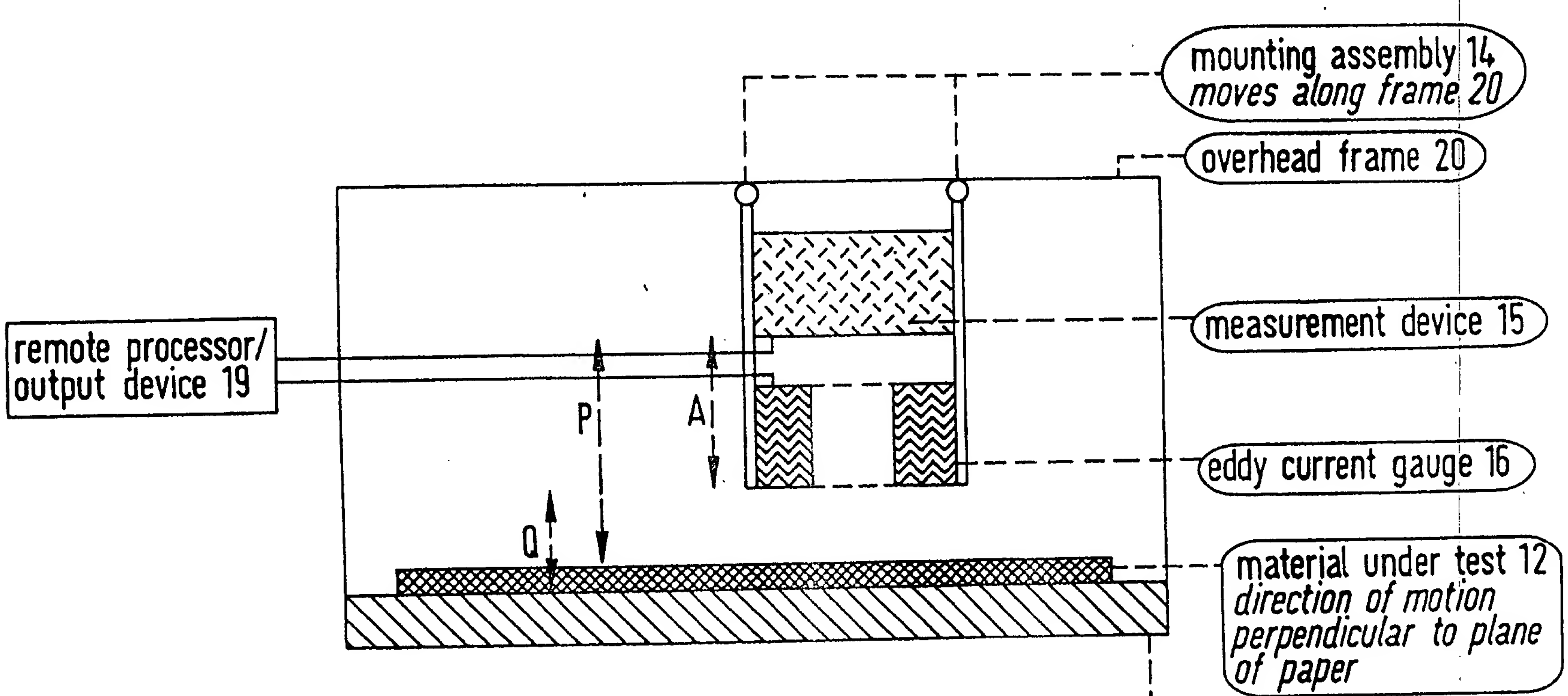

FIG.1

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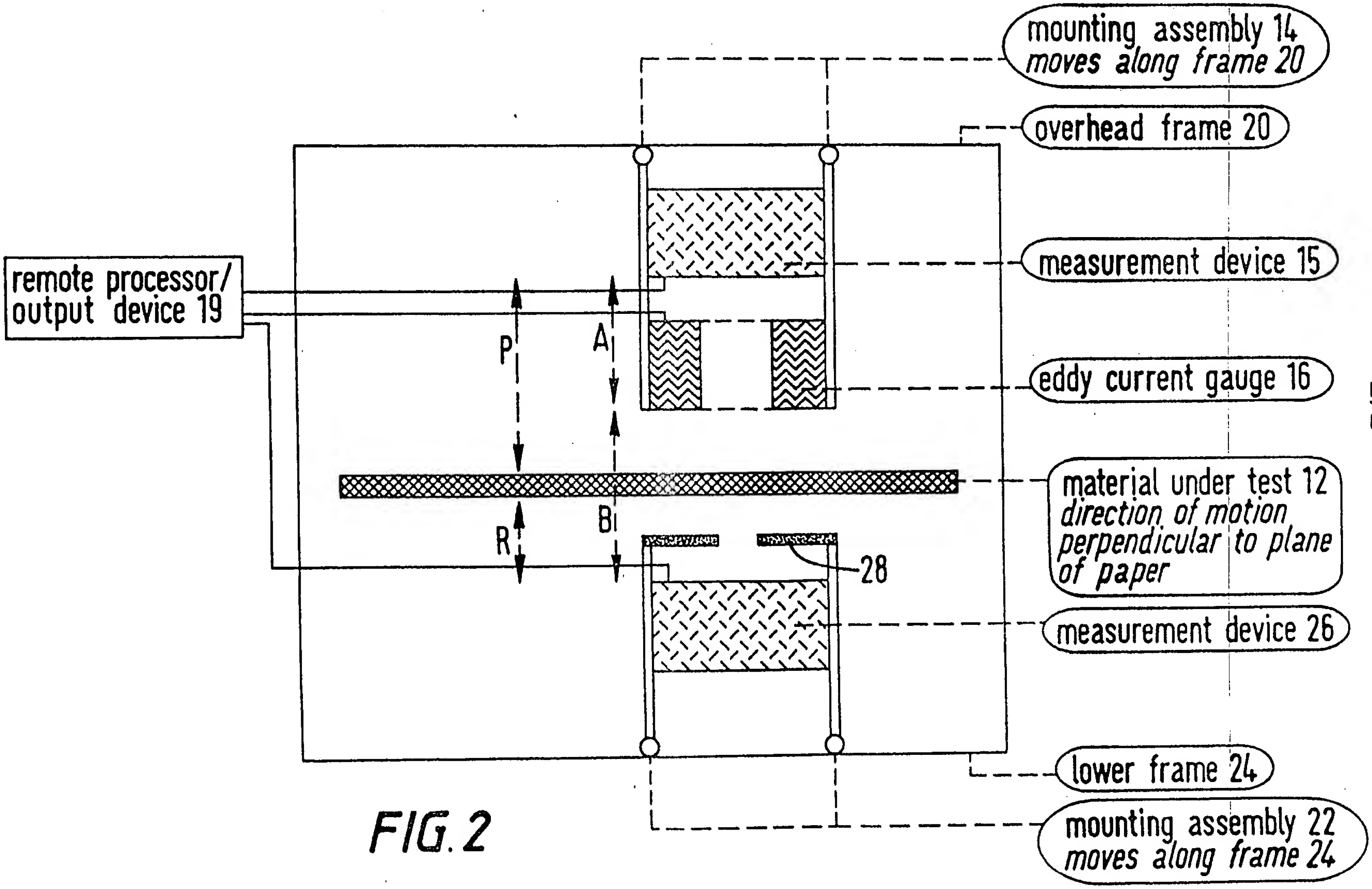

mounting assembly 14
moves along frame 20
overhead frame 20
measurement device 15
remote processor/
output device 19
P
A
eddy current gauge 16
material under test 12
direction of motion
perpendicular to plane
of paper
R
B
28
measurement device 26
lower frame 24
mounting assembly 22
moves along frame 24

FIG. 2

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THICKNESS MEASUREMENT DEVICE.

This invention relates to thickness measuring devices. It has particular application to devices which can measure the thickness of a magnetically transparent object to a relatively high degree of accuracy, typically to within one or two microns.

Known techniques for measuring the thickness of an object, typically non-metallic sheet material, to a high degree of accuracy fall into one of two categories. In the first the thickness of the object is determined by measuring the absorption of radiation such as beta particles transmitted through the object. The thickness of the object can be evaluated assuming that the absorption coefficient of the radiation is known for the material of the object, as well as its density.

The other known technique involves direct measurement of distance. In this technique, the object whose thickness is be measured, is located on a flat bed to which a rigid overhead frame is attached. This frame carries an ultrasonic, or a laser or other optical distance measuring device (hereinafter

referred to as the prime measuring device) which directs a beam of radiation towards the top surface of the object under test and senses the beam reflected back from that top surface. In this way the distance to the top surface of the object can be evaluated and knowing the distance to the bottom surface, namely the distance to the flat bed, the thickness of the object can be calculated. Other known devices permit the passage of the object between two oppositely disposed rigidly connected prime measuring devices which determine the position of the top and bottom surfaces of the material and hence the thickness of the object. Known devices require a very rigid frame in order to carry the measuring devices as distortions in the position of these devices generate errors in the calculated thickness measurement. This is because known devices rely on a knowledge of distance between two reference points in the structure of the measuring devices.

An object of the present invention is to provide a thickness measuring arrangement which does not suffer from this disadvantage.

According to the present invention there is provided a thickness measuring apparatus for measuring the thickness of an object which comprises a prime

measuring device of the type which measures distance to one surface of an object by transmitting radiation towards the object and sensing radiation reflected back from that surface and a second measuring device of the inductive type which is used to determine the position of a reference point or level, said second device having a region or zone through which radiation from the prime device can be transmitted and said first device being disposed generally coaxially with said gauge region or zone. In one form of the invention the reference point or level is the other surface of the object. In this type of arrangement the evaluation of thickness involves a subtraction step in which a distance measured by the first device is subtracted from a distance measured by the second device so that the effects of any distortion in the structure of the device tend to cancel each other out.

The inductive type gauge may be an eddy current type gauge and it may be generally toroidal in form. This gauge operates by virtue of the surface of the object being in contact with metal, e.g. a metal bed or roll.

The object may be located on a flat bed or roll and the gauge used to measure the distance to said bed or roll, the thickness calculation involving

subtraction of the distances measured by the first and second devices.

Alternatively the object may be located on supporting rollers or otherwise maintained such that a portion of the object to be measured is freely supported between spaced support points and the device may include a third measuring device of the prime type which measures distance to the other surface of the object, said third device being disposed generally coaxially with the first device, but on the opposite side of said object whereby it measures distance to the other surface of the object, and said gauge type device is used to measure distance to said third device or a point of reference on the mounting of said third device. In this arrangement the gauge is used to check for any errors which result, e.g. from movement of the third device when it is moved relative to the object to measure the thickness at various points over the object.

The first and third devices may be optical, e.g. laser type devices or ultrasonic type devices.

The invention will be described now by way of example only, with particular reference to the accompanying drawings. In the drawings:

Figure 1 is a schematic view of a thickness

measuring device in accordance with the present invention; and

Figure 2 is a view similar to Figure 1 of a modified form of the invention.

Referring to the drawings, a thickness measuring apparatus comprises a flat metal bed 10 having an accurately machined surface. A sheet-like object 12 formed of a material which is magnetically transparent and whose thickness is to be measured, is located on this metal bed. The object to be measured may be stationary or moving. Disposed above the metal bed 10 and spaced therefrom so that the object can pass beneath it is a mounting arrangement 14 for two measuring devices. The mounting arrangement is suspended from a frame 20 so that it can move along the frame. A first measuring device indicated generally at 15 is a device of the type which is arranged to transmit radiation, e.g. laser light or ultrasound, towards the object 12 and to sense radiation reflected back from the upper surface of the object. The second measuring device shown at 16 is a toroidal eddy current gauge. Thus the eddy current gauge has a central region or zone which is transparent to radiation from the device 15, and the device 15 is mounted generally coaxially above that

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region or zone so that the radiation is transmitted substantially centrally through the aperture in the eddy current gauge. The first and second measuring devices are electrically connected to a processing device 19 so that the device 19 can process output signals received from the measuring devices.

In use of the apparatus the laser device 15 transmits radiation towards the object 12 and light is reflected back from the upper surface of the object 12 to the laser device 15. If the object 12 is in motion, it will be moving along a direction perpendicular to the plane of the drawing. By sensing the reflected light this device measures the distance P shown on the drawing. The eddy current gauge is used to measure the distance from the device to the surface of the metal bed 10. This corresponds to the lower surface of the object 12. Knowing the distance A which is a constant, it can thus be seen that the thickness of the object can be calculated by a simple arithmetic operation. This operation involves subtraction of the measurements P and Q and hence, any errors arising from distortion of the frame which carried the two measuring devices 15 and 16, tend to cancel out in this subtraction process. These arithmetic operations are carried out by the processor 19.

A significant feature of the arrangement is that the devices 15 and 16 are located generally coaxially so that there are substantially no errors arising from any lack of parallelism between the surface of the test bed and the measuring devices 15, 16. Furthermore the assembly of devices 15 and 16 is mounted on the overhead frame shown at 20, so that it can be moved relative to the object 12 to measure the thickness of the object at different points across the object. The measurement technique is such that any displacement of the measuring devices 15 and 16 as a result of such movement does not affect the resulting thickness measurement because of the fact that the calculation of thickness involves subtraction of the distances P and Q.

An alternative arrangement shown in Figure 2 makes use of rollers in place of the metal bed 10. In this alternative arrangement the rollers (not shown) are spaced apart so that the object 12 can be supported between them in a manner similar to that described above, but without the metal bed. A second laser-type measuring device 26 is located below the object so that it can be used to evaluate the distance to the lower surface of the object. The second laser-type device 26 is supported on a mounting assembly 22

which can move along a frame 24. In this arrangement the eddy current gauge 16 is used to sense distance to this second measuring device. To enable this to be achieved the device 26 is provided with a metallic target 28 which acts a reference point for the eddy current gauge.

In the arrangement show in Figure 2 the thickness of the object is given by (A+B) - (P+R), this being evaluated by the processor 19 in response to electrical signals received from the devices 15, 16 and 26.

CLAIMS:

1. A thickness measuring apparatus for measuring the thickness of an object which comprises a prime measuring device of the type which measures distance to one surface of an object by transmitting radiation towards the object and sensing radiation reflected back from that surface and a second measuring device of the inductive type which is used to determine the position of a reference point or level, said second device having a region or zone through which radiation from the prime device can be transmitted and said first device being disposed generally coaxially with said gauge region or zone.

2. A thickness measuring apparatus according to claim 1 wherein said reference point or level is the other surface of the object.

3. Apparatus according to claim 1 or claim 2, wherein the inductive type gauge comprises an eddy current type gauge.

4. Apparatus according to claim 3, wherein the eddy current gauge is coreless and generally toroidal in form.

5. Apparatus according to any preceding claim, wherein the object is arranged to be located on a flat bed or roll and the second device is used to measure the distance to said bed or roll, the thickness calculation involving subtraction of the distances measured by the first and second devices.

6. Apparatus according to claim 1, wherein the object is arranged to be located on supporting rollers or otherwise maintained such that a portion of the object to be measured is freely supported between spaced support points and the apparatus includes a third measuring device of the prime type which measures distance to the other surface of the object, said third device being disposed generally coaxially with the first device, but on the opposite side of said object whereby it measures distance to the other object whereby it measures distance to the other surface of the object, and said inductive device is used to measure distance to said third device or a point of reference on the mounting of said third device.

7. Apparatus according to any one of claims 1 to 6, wherein the first device is an optical type device such as a laser device.

8. Apparatus according to any one of claims 1 to 6, wherein the first device is an ultrasonic type device.

9. Apparatus according to any one of claims 6 to 8, wherein the third device is an optical type device such as a laser device.

10. Apparatus according to any one of claims 6 to 8, wherein the third device is an ultrasonic type device.

11. Thickness measuring apparatus substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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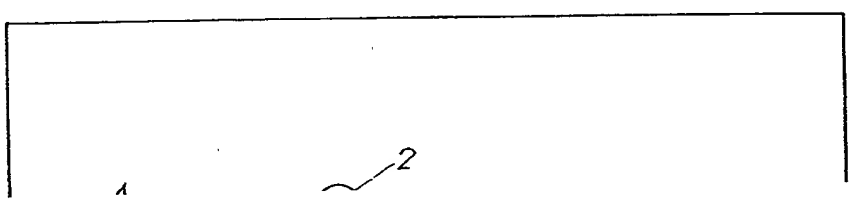
(71) Applicant David Theodore Nelson Williamson, 55 Kenwyn Road, London
(72) Inventor David Theodore Nelson Williamson
(74) Agent 44, Kenwyn Road, London

(54) **Thickness measuring apparatus**

(57) An apparatus for measuring the thickness of a material 1 comprises a magnet 4 and measuring coil 3 assembly and a magnetically-permeable freely-movable object, such as a steel ball 2, placed on the side of the material opposite from that of the assembly 3, 4, the arrangement being such that the object 2 is constrained by the field of the magnet 4 and the position thereof is sensed by means of the modification of the electric signals in the coil 3 due to the inductive effect of the object 2. An auxiliary measuring system comprising a non metallic probe 5 which is connected to one part of a two part transducer 7 may also be provided for measuring the distance between the coil and the adjacent surface of the material. Alternatively the auxiliary measuring system may be replaced by a balance unit 12, 13, 14, 15 connected in a bridge with the coil 3, the ball 12 thereof being movable relative to the coil 13 by a micrometer or other measuring device so as to balance the bridge and hence provide a measure of the movement of the object 2.



ERRATUM

SPECIFICATION NO 2035566A

Front page, Heading (71) Applicant *delete* 55 Kenwyn *insert* 44 Kenwyn

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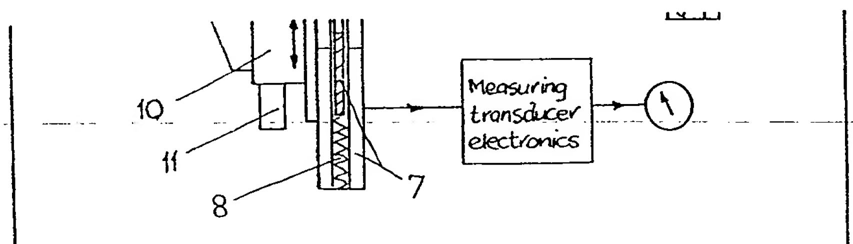

Fig 1

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